One-line γ ray spectroscopic investigation of the 180Hg(T 1/2 = 3 s) decay chain

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Classification
Physics Abstracts
21.10H — 23.20C

ONE-LINE γ RAY SPECTROSCOPIC INVESTIGATION OF THE ^{180}Hg($T^{1/2}$ = 3 s) DECAY CHAIN

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(*Reçu le 5 avril 1977, révisé le 6 juin 1977, accepté le 7 juin 1977*)

Résumé. — Avec le séparateur ISOLDE 2 reconstruit, nous avons étudié en ligne pour la première fois les produits de désintégration du $^{180}_{80}$Hg. Les périodes de désintégration, les intensités des principales transitions γ des désintégrations du ^{180}Hg($T^{1/2}$ = 3,0 ± 0,3 s) et de $^{180}_{79}$Au($T^{1/2}$ = 8,1 ± 0,3 s) et un schéma partiel des états excités de $^{180}_{78}$Pt sont présentés.

Abstract. — With the rebuilt ISOLDE 2 facility we have investigated on-line the $^{180}_{80}$Hg decay products. The decay half-lives, the energies and intensities of the main γ lines of both

$$^{180}\text{Hg}(T^{1/2} = 3.0 \pm 0.3\ \text{s}) \quad \text{and} \quad ^{180}_{79}\text{Au}(T^{1/2} = 8.1 \pm 0.3\ \text{s}),$$

and a tentative decay scheme of $^{180}_{78}$Pt are given.

1. **Introduction.** — Using the ISOLDE 2 facility one-line with the reconstructed 600 MeV-proton synchrocyclotron, we have investigated the $A = 180$ mercury decay products for the first time with our new tape transport system. The molten lead target is bombarded by 600 MeV protons, spallation reactions (p, 3pxn) are induced and neutron deficient mercury nuclei are produced and mass-separated by the ISOLDE 2 separator. The weakness of the cross-section for the reaction (p, 3p 26n) is such that an increased intensity of the proton beam will be necessary for further studies.

Before this work the α-decay systematic study of Hg isotopes and also the delayed-proton emission characteristics were studied by another ISOLDE team [1, 2]. In this letter we present the half-live measurements based on multianalysis for the main γ transitions belonging to the $^{180}_{79}$Au decay. Although no γ-γ coincidence experiments could be performed, we propose a possible low-energy decay scheme of the $^{180}_{78}$Pt nucleus.

2. **Experimental procedure.** — Due to the γ background and to the low production of this mass ($\sim$ 10 at/s) we performed a β-γ coincidence experiment. The separated beam of ^{180}Hg ions was deposited on the tape of the new moving tape collector system. The tape is then moved to the centre of a 4 π plastic scintillator detector. A LASCO 50 cm^3 Ge(Li) detector is positioned in front of this detector; the activity of interest is enhanced by proper timing selection of collection, delay and counting time; this procedure is repeated as long as is required. The γ energy spectrum in coincidence with the plastic β counter pulses is converted in an Analog to Digital Converter (Intertechnique CT 103) on-line with a Plurimat computer system. The experimental set up arrangement is similar to that described by F. K. Wohn *et al.* [3].

Two experiments were done simultaneously during a 48 hours period. On the Plurimat computer system a time-γ energy multianalysis (8 × Δt × 1 024 channels) was recorded (Δt_1 = 4 s, Δt_2 = 6 s). On a separate

multichannel analyser a 4 k γ-energy spectrum was constantly accumulated during the multianalysis experiment.

3. **Results.** — We have identified the main γ lines belonging to both mercury and gold decays (see Table I, Fig. 1, 2). We have followed the decay of the main γ lines in order to measure the half-lives and to confirm the attribution of the transitions to both decays. With a least-squares fitting code we obtain

for $^{180}_{80}Hg \rightarrow {}^{180}_{79}Au$ the half-life $T^{1/2} = 3.0 \pm 0.3$ s

for $^{180}_{79}Au \rightarrow {}^{180}_{78}Au$ the half-life $T^{1/2} = 8.1 \pm 0.3$ s.

A preliminary result from the ISOLDE Group [4] for the gold decay gave

$$T^{1/2} \sim 8.5 \text{ s}.$$

The first value for the $2^+ \rightarrow 0^+$ transition energy in $^{180}Au \rightarrow {}^{180}Pt$ given by P. Hornshøj *et al.* [2] was 150 ± 15 keV, obtained from the delayed-proton emission study of ^{181}Hg; we find 152.3 ± 0.3 keV.

TABLE I

Energies and relative intensities of the main γ transitions observed

$^{180}Au \rightarrow {}^{180}Pt$		$^{180}Hg \rightarrow {}^{180}Au$	
E_γ (keV)	I_r (relative intensity)	E_γ (keV)	I_r (relative intensity)
152.2 ± 0.3	100	125.0 ± 0.4	9.7 ± 2
256.4 ± 0.3	29.6 ± 6	300.5 ± 0.3	100
324.0 ± 0.3	17.7 ± 3.4	381.2 ± 0.4	69.3 ± 14
343.4 ± 0.3	13.6 ± 2.8	(405.0 ± 0.5)	~ 17
(450.5 ± 0.5) (1)	~ 7	(450.5 ± 0.5) (1)	~ 16
524.2 ± 0.3	44 ± 6.6	479.9 ± 0.4	23 ± 4.5
(552.4 ± 0.4)	~ 6.5		
676.5 ± 0.4	20 ± 4		
(707.7 ± 0.5)	~ 4		
808.4 ± 0.4	30 ± 6		
859.7 ± 0.6	35 ± 7		
1 032.1 ± 0.7	23 ± 4.5		

(1) Transition belonging to both decays transitions in ( ) are weak.

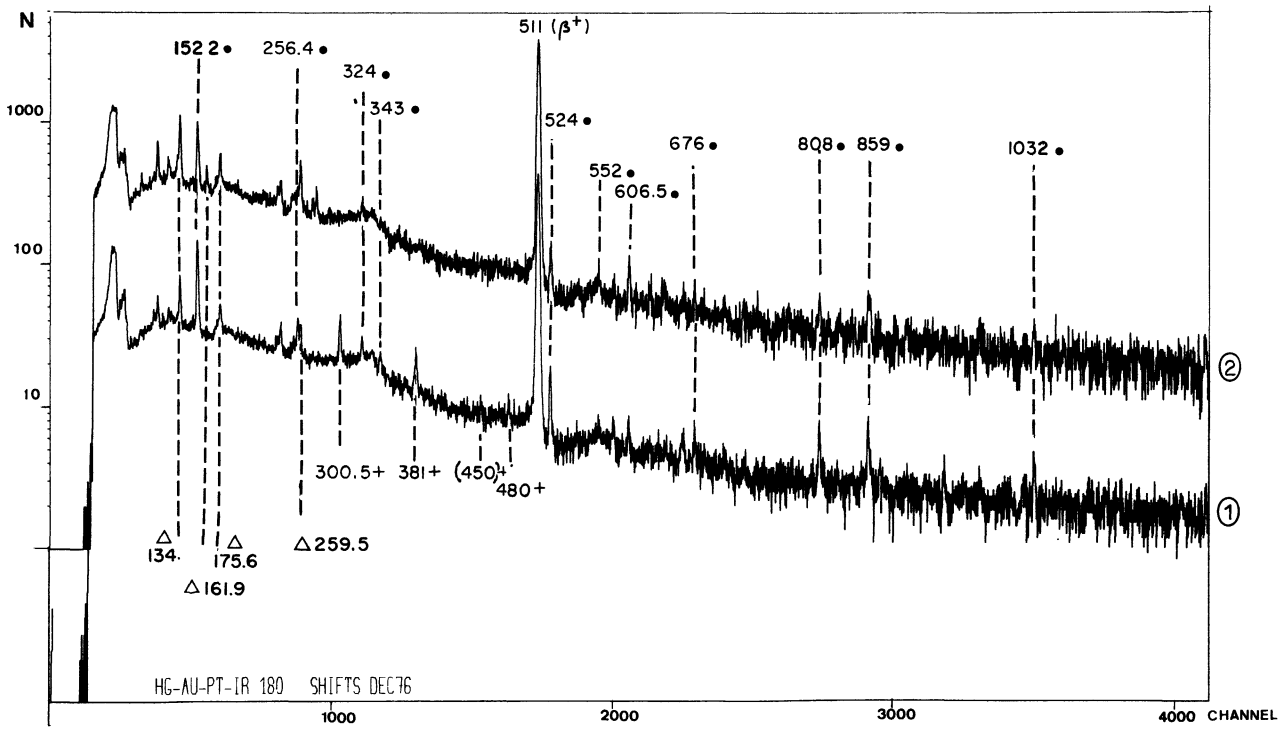

FIG. 1. — Accumulated γ-ray spectra from Hg → Au → Pt decays of mass 180 (+ Hg → Au, ● Au → Pt, Δ Pt → Ir → Os). Spectrum 1 is recorded with 8 s collection, 0 s delay, and 8 × 4 s measurement (Hg → Au → Pt favoured). Spectrum 2 is recorded with 15 s collection, 8 s delay, and 8 × 6 s measurement (Au → Pt → Ir → Os favoured).

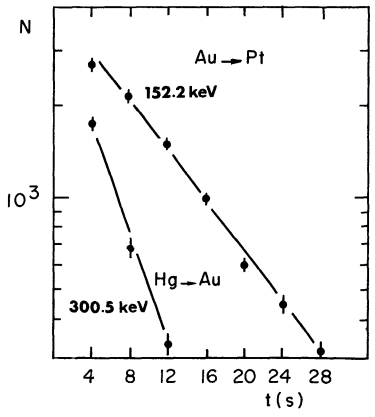

FIG. 2.—Example of the half-life determination in the $A = 180$ chain.

It is possible that some of our γ lines attributions are perturbed by the decay of the parallel chain coming from the α branching of

$$^{180}_{80}\mathrm{Hg} \xrightarrow{\alpha} {}^{176}_{78}\mathrm{Pt} \xrightarrow[8\,s]{\text{E.C.},\beta^+} {}^{176}_{77}\mathrm{Ir}\,.$$

Unfortunately the γ transitions of these decays are unknown [5]. We have considered that only the γ lines whose relative intensity with respect to the strongest γ line at 152.3 keV was conserved with two different timing measurements could be assigned to the ^{180}Au decay. On the other hand no ambiguity occurs for the γ lines attributed to the ^{180}Hg → ^{180}Au decay.

4. **Discussion.** — Due to the weakness of the production we could not perform any γ-γ or e^--γ coincidence experiments to support our level scheme proposal.

By performing simple sum relationships calculations with the transition energies and comparing with the excited levels systematics of the heavier platinum nuclei [6, 7] (see Fig. 3) we propose a partial scheme (see Fig. 4). We believe we have identified the 2_1^+, 4_1^+, 2_2^+, 3_1^+, 2_3^+ states.

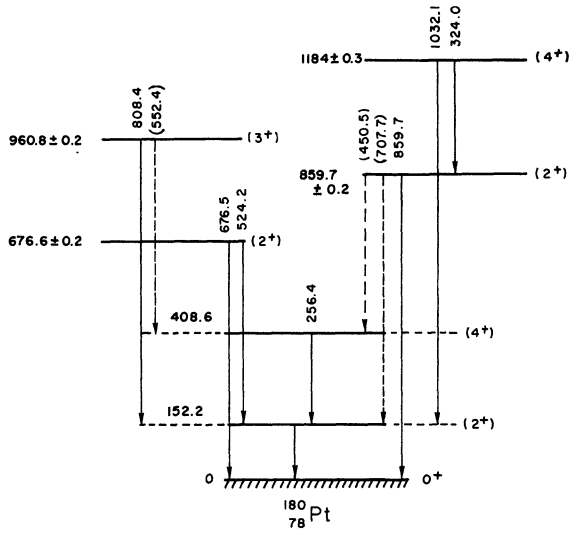

FIG. 4. — Partial decay scheme of $^{180}_{79}$Au → $^{180}_{78}$Pt.

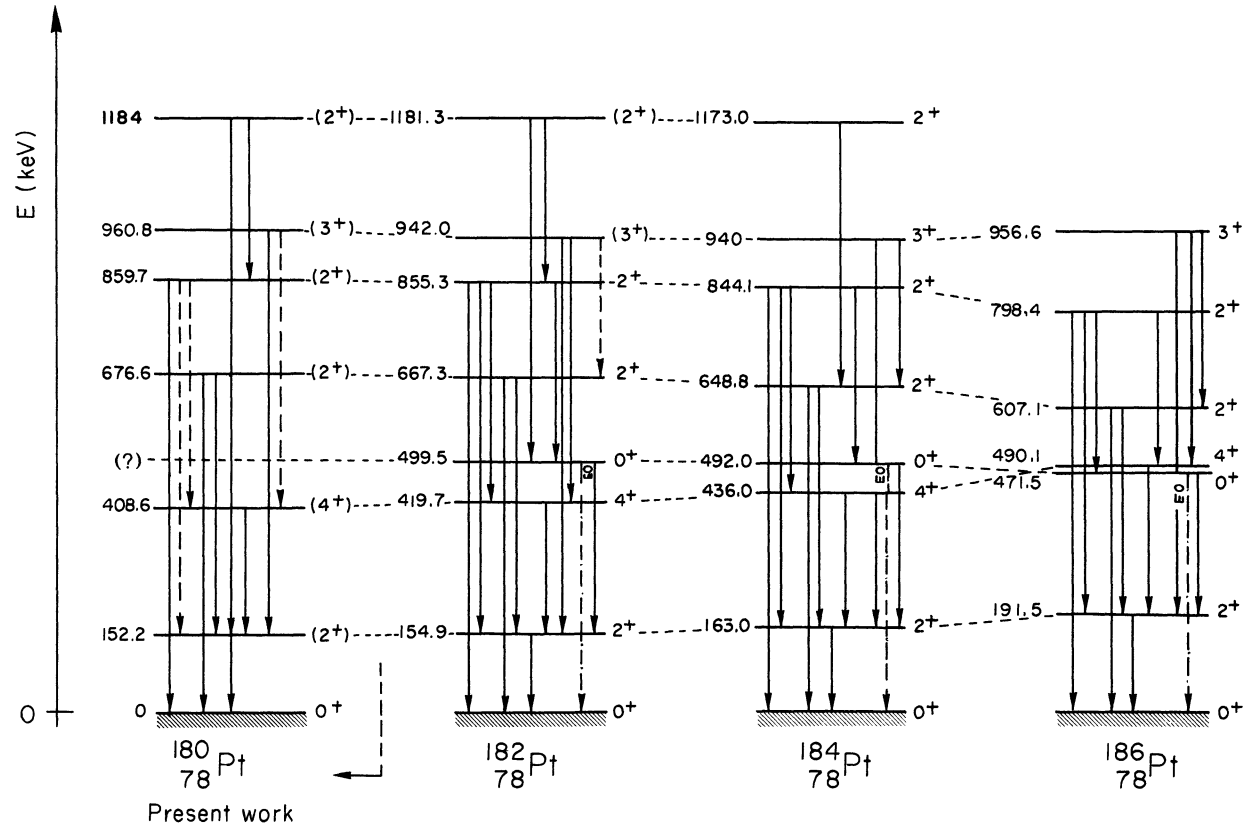

FIG. 3. — Systematics of the excited levels of ^{180,182,184,186}Pt nuclei.

These assumptions are in agreement with our previous interpretation [6, 7] of the behaviour of the neutron deficient platinum isotopes : in fact, the prolate-oblate shape transition occurs from ^{186}Pt to ^{188}Pt and the three nuclei ^{180,182,184}Pt show a rather similar level structure not yet perturbed, slowly varying with little energy differences. In particular the ^{180}Pt nucleus cannot be considered as truly rotational : the ratio

$$\frac{B(\mathrm{E2}\,;\,2_2^+ \to 0_1^+)}{B(\mathrm{E2}\,;\,2_2^+ \to 2_1^+)} \simeq 0.14$$

is still far from the 0.7 rotational limit value as is the energy ratio $E4_1^+/E2_1^+ = 2.68$ compared to the 3.3 limit; the three nuclei ^{180,182,184}Pt remain slightly deformed ($\beta > 0$) but still transitional.

In conclusion, other experiments are necessary to confirm this tentative interpretation of the ^{180}Pt nucleus (0_2^+ excited state location, etc...) but we believe that this nucleus, far from the β stability line, is slightly prolate, and below 1.2 MeV, shows similar properties to those of ^{182,184}Pt nuclei.

The authors are indebted to G. Walter, R. Huck and A. Knipper for providing the plastic scintillator set-up which made the experiment possible.

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